



# MPR121 GPIO and LED Driver Function

## INTRODUCTION

MPR121 is a feature rich second generation touch sensor controller after Freescale's initial release of the MPR03x series device. MPR121 not only has priority unique features like independent electrode auto configuration (refer to AN3889), 13th simulated pseudo electrode for proximity detection (refer to AN3893), it also has 8 GPIO ports with LED driver capability. The GPIO and LED driver function can be used when not all the 12 input sensing channels are occupied for touch sensing detection, which is made possible by internal multiplexed pin structure. This increases the cost efficiency of the system and makes the MPR121 fit for even wider application.

## MULTIFUNCTION PINS

MPR121 has 12 input sensing channels ELE0~ELE11, which occupies pin 8 to pin 19. Among these, pin 12 to pin 19 are multifunction pins. When these multifunction pins are not configured as electrodes, they may be used to drive LED or for general GPIO purpose.

PIN #	8	9	10	11	12	13	14	15	16	17	18	19
ELECTRODE	ELE0	ELE1	ELE2	ELE3	ELE4	ELE5	ELE6	ELE7	ELE8	ELE9	ELE10	ELE11
GPIO	—	—	—	—	GPIO0	GPIO1	GPIO2	GPIO3	GPIO4	GPIO5	GPIO6	GPIO7

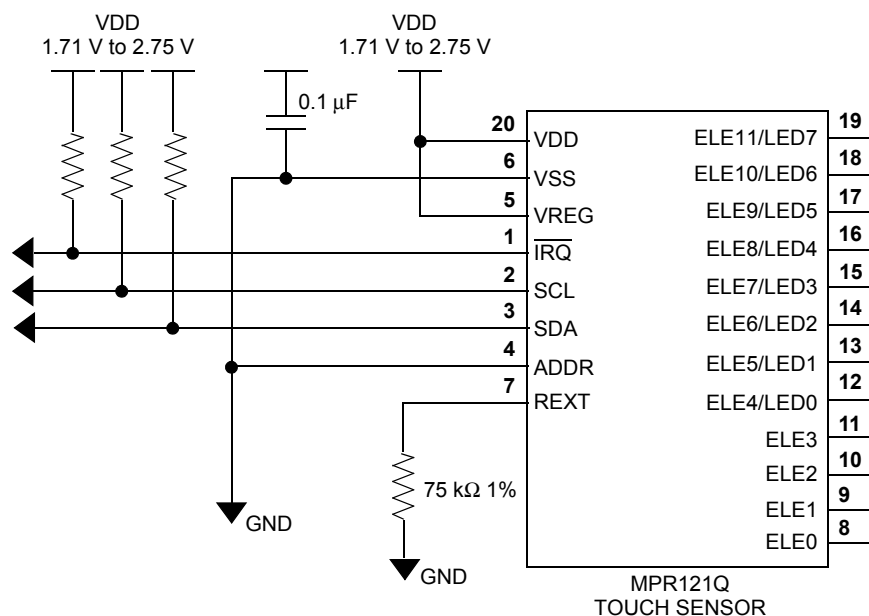
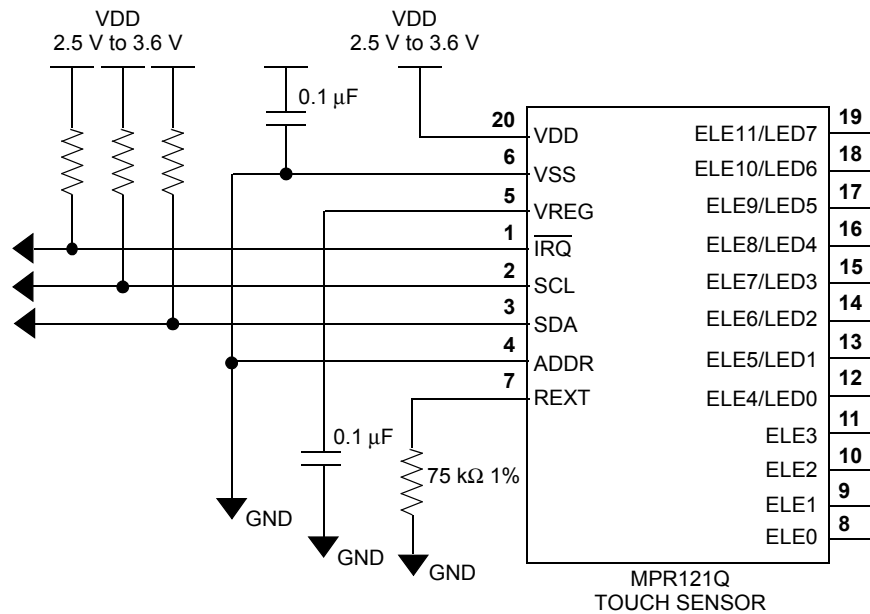


Figure 1. Configuration 1: MPR121 runs from a 1.71 V to 2.75 V supply.



**Figure 2. Configuration 2: MPR121 runs from a 2.5 V to 3.6 V supply.**

These registers control GPIO function. D7~D0 bits corresponds GPIO7~GPIO0 pins respectively. The GPIO control registers can write always regardless Shutdown and Run mode.

**Table 1. GPIO Control Registers**

Name	Address	D7	D6	D5	D4	D3	D2	D1	D0
GPIO Control 0	0x73	CTL0[7]	CTL0[6]	CTL0[5]	CTL0[4]	CTL0[3]	CTL0[2]	CTL0[1]	CTL0[0]
GPIO Control 1	0x74	CTL1[7]	CTL1[6]	CTL1[5]	CTL1[4]	CTL1[3]	CTL1[2]	CTL1[1]	CTL1[0]
GPIO Data	0x75	DAT[7]	DAT[6]	DAT[5]	DAT[4]	DAT[3]	DAT[2]	DAT[1]	DAT[0]
GPIO Direction	0x76	DIR[7]	DIR[6]	DIR[5]	DIR[4]	DIR[3]	DIR[2]	DIR[1]	DIR[0]
GPIO Enable	0x77	EN[7]	EN[6]	EN[5]	EN[4]	EN[3]	EN[2]	EN[1]	EN[0]
GPIO Data Set	0x78	SET[7]	SET[6]	SET[5]	SET[4]	SET[3]	SET[2]	SET[1]	SET[0]
GPIO Data Clear	0x79	CLR[7]	CLR[6]	CLR[5]	CLR[4]	CLR[3]	CLR[2]	CLR[1]	CLR[0]
GPIO Data Toggle	0x7A	TOG[7]	TOG[6]	TOG[5]	TOG[4]	TOG[3]	TOG[2]	TOG[1]	TOG[0]

**EN[7:0], DIR[7:0], CTL0[7:0], CTL1[7:0]: Configuration Register**

The number of touch sensing electrodes (and therefore the number of GPIO ports available) is configured by the Electrode Configuration register (0x5E) and GPIO Enable Register (0x77), but electrode configuration has higher priority than GPIO feature. When a pin is enabled as GPIO but is also selected as electrode by Electrode Configuration Register, the GPIO function is disabled immediately and it becomes an electrode during Run mode. But all 8 ports automatically become GPIO ports in Shutdown mode because none of the ports are being enabled as touch electrodes in Shutdown mode.

During the shutdown mode just after power on reset, all 8 GPIO ports are in high impedance as all the GPIO ports are default disabled. Take care to program unused ports which are not going to be used as either touch electrodes or GPIO to avoid floating inputs or outputs shorted to a rail. One approach is to enable unused ports to be GPIO inputs with internal pull-up or pull-down.

The GPIO system allows the GPIO pins to be set as input or output. When an EN bit sets, the corresponding GPIO pin is enabled and the function is configured by CTL0, CTL1 and DIR bits. When the port is used as input, it can be configured as normal input or with additional internal pull-down or pull-up for input port. For output configuration, it can be push/pull or open drain.

EN	DIR	CTL[0:1]	DESCRIPTION
0	X	XX	GPIO function is disabled. Port is high-z state.
1	0	00	GPIO port becomes input port.
1	0	10	GPIO port becomes input port with internal pull-down.
1	0	11	GPIO port becomes input port with internal pull-up.
1	0	01	Not defined yet (as same as CTL = 00).
1	1	00	GPIO port becomes CMOS output port.
1	1	11	GPIO port becomes high side only open drain output port for LED driver.
1	1	10	GPIO port becomes low side only open drain output port.
1	1	01	Not defined yet (as same as CTL = 00).

#### DAT[7:0]: Data Register

When a GPIO is as output, the GPIO port outputs the bit level of this register. The output level toggle holds on any electrode charging and AD conversion and the level transition will be occurred after the AD conversion. Reading this register returns the content of the DAT register (not a level of the port).

When a GPIO is as input, reading this register returns latched input level of the corresponding port (not contents of the DAT register). A write changes content of the register, but not affect to the input function.

#### SET[7:0]: Set Data Register

Writing a “1” to bits in this register will set them in the Data Register.

#### CLR[7:0]: Clear Data Register

Writing a “1” to bits in this register will clear them in the Data Register.

#### TOG[7:0]: Toggle Data Register

Write a bit with “1” to the GPIO Data Set Register, GPIO Data Clear Register, and GPIO Toggle Register set/clear/toggle contents of the corresponding DAT bit. Write “0” has no meaning. Using of those registers allows any individual port(s) to be able individually set, cleared, or toggled without affecting other ports. Reading those register returns as same as DAT register reading.

### LED DRIVER

Each GPIO pin has LED driver capability which can source up to 12 mA. When GPIO is used to driver LED, connect the GPIO output to an LED forward biased with its cathode to GND so that GPIO output high lights the LED. Place a current limiting resistor in series with LED to limit the current below 12 mA (refer to the typical application circuit).

When LED dimming control is needed, the PWM control register can be set to get the desired dimming control. Alternatively, the PWM can also be used to drive the beeper.

**Table 2. PWM\_[3:0]: PWM Duty Control Registers**

Name	Address	D7	D6	D5	D4	D3	D2	D1	D0
PWM 0	0x81	PWM1[3]	PWM1[2]	PWM1[1]	PWM1[0]	PWM0[3]	PWM0[2]	PWM0[1]	PWM0[0]
PWM 1	0x82	PWM3[3]	PWM3[2]	PWM3[1]	PWM3[0]	PWM2[3]	PWM2[2]	PWM2[1]	PWM2[0]
PWM 2	0x83	PWM5[3]	PWM5[2]	PWM5[1]	PWM5[0]	PWM4[3]	PWM4[2]	PWM4[1]	PWM4[0]
PWM 3	0x84	PWM7[3]	PWM7[2]	PWM7[1]	PWM7[0]	PWM6[3]	PWM6[2]	PWM6[1]	PWM6[0]

PWM0[3:0] ~ PWM7[3:0] is used to set the PWM duty of GPIO0 ~ GPIO7 respectively. The power up reset default setting for these four register is 0x00. When a GPIO is programmed as output and the DAT register is “1” and if the corresponding PWM\_[3:0] register is not zero, the GPIO pin outputs PWM waveform. The PWM period is fixed 8ms (1/256 of 32 KHz OSC) and PWM\_[3:0] register decides duty of the waveform.

PWM_ [3:0]	Description (_ is 0~7)
0	PWM is off, GPIO outputs stable high when DAT register is “1”
1	GPIO output duty is 1:15 (mostly output low)
2	GPIO output duty is 2:14 (mostly output low)
—	—
15	GPIO output duty is 15:1 (mostly output high)

These register can be read/write any time, even if MPR121 is in Run Mode. When the register changes during PWM enables, a mixed duty cycle would be possible to occur.

The PWM duty is not so much accurate, because GPIO output transition (include PWM) inhibits during measurement state. Therefore, when interval time (=Touch Detection Sample Interval) is close to measurement time (depends on charge time, AFE Samples and number of measurement electrodes), the PWM operation is disturbed and the waveform couldn't keep programmed duty.

## How to Reach Us:

### Home Page:

[www.freescale.com](http://www.freescale.com)

### Web Support:

<http://www.freescale.com/support>

### USA/Europe or Locations Not Listed:

Freescale Semiconductor, Inc.  
Technical Information Center, EL516  
2100 East Elliot Road  
Tempe, Arizona 85284  
+1-800-521-6274 or +1-480-768-2130  
[www.freescale.com/support](http://www.freescale.com/support)

### Europe, Middle East, and Africa:

Freescale Halbleiter Deutschland GmbH  
Technical Information Center  
Schatzbogen 7  
81829 Muenchen, Germany  
+44 1296 380 456 (English)  
+46 8 52200080 (English)  
+49 89 92103 559 (German)  
+33 1 69 35 48 48 (French)  
[www.freescale.com/support](http://www.freescale.com/support)

### Japan:

Freescale Semiconductor Japan Ltd.  
Headquarters  
ARCO Tower 15F  
1-8-1, Shimo-Meguro, Meguro-ku,  
Tokyo 153-0064  
Japan  
0120 191014 or +81 3 5437 9125  
[support.japan@freescale.com](mailto:support.japan@freescale.com)

### Asia/Pacific:

Freescale Semiconductor Hong Kong Ltd.  
Technical Information Center  
2 Dai King Street  
Tai Po Industrial Estate  
Tai Po, N.T., Hong Kong  
+800 2666 8080  
[support.asia@freescale.com](mailto:support.asia@freescale.com)

### For Literature Requests Only:

Freescale Semiconductor Literature Distribution Center  
1-800-441-2447 or 303-675-2140  
Fax: 303-675-2150  
[LDCForFreescaleSemiconductor@hibbertgroup.com](mailto:LDCForFreescaleSemiconductor@hibbertgroup.com)

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals", must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.

Freescale and the Freescale logo are trademarks of Freescale Semiconductor, Inc., Reg. U.S. Pat. & Tm. Off.

All other product or service names are the property of their respective owners.

© Freescale Semiconductor, Inc. 2010. All rights reserved.